

[Name of document] SPECIFICATION

[Title of the invention] LIGHT DEFLECTING ELECTRIC MOTOR

[Claims]

[Claim 1] A light deflecting electric motor comprising a stator
5 assembly including a base, a fixed shaft fixed to the base and a stator
mounted on the base, a rotor assembly including a rotating member
rotatably mounted on a plurality of bearings further mounted on the fixed
shaft, a polygon mirror mounted on the rotating member and a rotor
mounted on the rotating member, characterized in that the rotor assembly
10 has a center of gravity located between the bearings, and by a balancing
plane provided in the vicinity of a plane which is perpendicular to a center
of rotation of the rotor assembly and passes the center of gravity of the
rotor assembly.

[Claim 2] The motor according to claim 1, characterized in that
15 each bearing comprises a ball bearing including a number of rolling
members each made of ceramic.

[Claim 3] The motor according to claim 1 or 2, characterized in
that the rotor assembly has a balancing groove formed in a portion thereof
located below the bearings.

20 [Claim 4] The motor according to claim 3, characterized in that the
rotor includes a rotor magnet radially opposed to the stator with respect to
the rotor and a rotor yoke provided on the rotating member to hold the
rotor magnet, and the balancing groove is formed in the rotor yoke.

25 [Claim 5] The motor according to claim 3, characterized in that the
rotor includes a rotor magnet radially opposed to the stator with respect to
the rotor and a rotor yoke provided on the rotating member to hold the
rotor magnet, and the balancing groove is formed in the rotating member.

[Claim 6] The motor according to claim 3, characterized in that the

rotor includes a rotor magnet radially opposed to the stator with respect to the rotor and a rotor yoke provided on the rotating member to hold the rotor magnet, and the balancing groove is defined between the rotating member and the rotor yoke.

5 [Claim 7] The motor according to any one of claims 3 to 6, characterized in that the balancing groove is disposed inside a reflecting surface of the polygon mirror.

[Detailed description of the invention]

[0001]

10 [Field of the invention]

This invention relates to a light deflecting electric motor for scanning laser beams used in an optical system of laser printers, digital copiers, etc.

[0002]

[Problem to be solved by the invention]

15 One of conventional light deflecting electric motors of the above-described type is explained with reference to FIG. 6. As shown in FIG. 6, a base 1 has a recess 1a in which an upper protrusion 2 is formed, and a lower protrusion 3 is formed on an underside of the base 1. The upper and lower protrusions 2 and 3 are formed with a through hole 8 vertically extending them. A rotational shaft 9 is rotatably mounted via bearings 10 in the hole 8.

[0003]

25 A balancing member 11 is fixed to a lower end of the shaft 9 by a bolt 11a. A bottom cover 12 is mounted on the bottom of the lower protrusion 3 so as to receive the shaft 9 via the balancing member 11 and the bolt 11a. A coil spring 13 is interposed between the lower bearing 10 and the balancing member 11 to downwardly urge the shaft 9.

[0004]

A stator 4 is fixed on an outer circumferential face of the upper protrusion 2. The stator 4 includes a stator core 5 made of laminated steel sheets, a coil 6 wound on the stator core 5, and a stator yoke 7 fixed on the stator core 5.

5 [0005]

A mirror mounting member 15 is mounted on an upper portion of the rotational shaft 9. A polygon mirror 16 is fixed to an upper face of the mirror mounting member 15. A rotor yoke 17 is fixed to an underside of the mirror mounting member 15. The rotor yoke 17 includes a rotor magnet 18 disposed opposite the stator 4. The rotor yoke 17 and the rotor magnet 18 constitute a rotor 14 of the motor.

10 [0006]

In the foregoing light deflecting motor, the stator 4 is controlled to be energized so that the polygon mirror 16 is rotated with the rotor 14. 15 The polygon mirror 16 is caused to oscillate upon high-speed rotation if one or more of rotating members K including the rotational shaft 9, mirror mounting member 15, polygon mirror 16, rotor yoke 17 and rotor magnet 18 are unbalanced. The oscillation of the polygon mirror 16 causes a laser beam reflected on it to deviate from a predetermined location, 20 resulting in deterioration in printing quality in the laser beam printer, for example. Balance adjustment is conventionally carried out for the rotating members K to prevent deterioration in the printing quality.

[0007]

More specifically, the balance adjustment is carried out both on the 25 upper face of the polygon mirror 16 and on the upper face of the balancer 11. This manner is referred to as "two-plane balancing." A balancing weight is placed on the upper face of the polygon mirror 16. The upper face of the balancer 11 is cut away or otherwise machined so that the

balance is adjusted.

[0008]

The weight of the polygon mirror accounts for a large percentage of the total weight of the rotating members K. Accordingly, the center of gravity of the rotating members K in the assembled state depends upon a location of the polygon mirror. Since the polygon mirror 16 occupies an upper part of the assembled rotating members K in the above-described motor, the center of gravity of the assembled rotating members K is located between the upper bearing 10 and the polygon mirror 16. When 10 the center of gravity of the rotating members K is thus located above the upper bearing 10, the rotating members K are rotated like a pestle during high-speed rotation while being oscillated. As a result, the oscillation of the rotating members K or more specifically of the polygon mirror 16 is increased.

15 [0009]

Further, when the balance adjusting face is located on the upper face of the polygon mirror 16 or on the lower end of the shaft 9, a balance weight is disposed radially or axially away from the center of gravity of the rotating members K or a portion of the member located radially or 20 axially away from the center of gravity of the rotating members K is cut away. Accordingly, even if the rotating members K are balanced as a whole, unbalance in the weight occurs at portions away from the center of gravity of the rotating members K. Thus, when the weight unbalance occurs axially away from the center of gravity of the rotating members K, 25 the polygon mirror 16 is subjected to a large gyroscopic moment thereby to be rotated during the high-speed rotation while being oscillated, whereupon the oscillation is further increased.

[0010]

Therefore, an object of the present invention is to provide a light deflecting electric motor in which an amount of oscillation of the polygon mirror during the high-speed rotation can be reduced.

[0011]

5 [Means for solving the problem]

A light deflecting electric motor of claim 1 of the present invention comprises a stator assembly including a base, a fixed shaft fixed to the base and a stator mounted on the base, a rotor assembly including a rotating member rotatably mounted on a plurality of bearings further 10 mounted on the fixed shaft, a polygon mirror mounted on the rotating member and a rotor mounted on the rotating member, characterized in that the rotor assembly has a center of gravity located between the bearings, and by a balancing plane provided in the vicinity of a plane which is 15 perpendicular to a center of rotation of the rotor assembly and passes the center of gravity of the rotor assembly.

[0012]

According to the above-described construction, the balancing plane of the rotor assembly is substantially co-planar with a plane passing the center of gravity of the rotor assembly. Consequently, since the 20 occurrence of gyroscopic moment is prevented in the rotor assembly during the high-speed rotation, the rotor assembly can be prevented from being oscillated. Further, the center of gravity of the rotor assembly is located between the bearings. Accordingly, even when unbalanced, the rotor assembly can further be prevented from being oscillated.

25 [0013]

In this case, each bearing preferably comprises a ball bearing including a number of rolling members each made of ceramic (the invention claimed in claim 2). When each bearing comprises the ball

bearing, the oscillation of the rotor assembly resulting from the unbalance in the weight thereof can be restrained or limited by the rigidity of each bearing. Further, when each bearing comprises the ball bearing, the rolling members roll with rotation of the rotor assembly such that the 5 rolling members are worn or the temperatures of the rolling members are increased. The wear or temperature increase of the rolling members causes changes in the accuracy of the bearing. However, ceramic is hard to wear and is less adversely affected by heat. Consequently, changes in the accuracy of the bearing can be prevented and accordingly, the service 10 life of each bearing can be improved.

[0014]

The rotor assembly preferably has a balancing groove formed in a portion thereof located below the bearings (the invention claimed in claim 3). According to the foregoing construction, the balancing weight can be 15 reduced since a location where balancing is carried out is axially spaced away from the center of gravity of the rotor assembly.

[0015]

The balancing groove is preferably formed in the rotor yoke or the rotating member, or defined between the rotating member and the rotor 20 yoke when the rotor includes a rotor magnet radially opposed to the stator with respect to the rotor and a rotor yoke provided on the rotating member to hold the rotor magnet (the inventions claimed in respective claims 4 to 6).

[0016]

25 The balancing groove is preferably disposed inside relative to the reflecting surface of the polygon mirror (the invention claimed in claim 7). According to this construction, if a balancing weight inserted into the groove for balancing should fly out of the groove during high-speed

rotation, the balancing weight can be prevented from adhering to the reflecting surface of the polygon mirror.

[0017]

[Embodiments of the invention]

5 Several embodiments of the present invention will be described with reference to FIGS. 1 to 5. Firstly, FIG. 1 shows a first embodiment of the invention. In FIG. 1, a base 21 is formed into a disk shape having a hollow protrusion 21a formed on an upper face thereof. An annular stator core 22 is fitted with the protrusion 21a to be fixed thereto. A stator coil 10 23 is wound on the stator core 22. The stator core 22 and the stator coil 23 constitute a stator 24 of the motor. The protrusion 21a has a vertically extending through hole 21b. A fixed shaft 25 is fitted in the hole 21b. The base 21, stator 24 and fixed shaft 25 constitute a stator assembly 40.

15 [0018]

 A housing 27 serving as a rotating member is rotatably mounted on a plurality of, for example, two vertically spaced-apart bearings 26 further mounted on an upper portion of the shaft 25 extending out of the protrusion 21a. In the embodiment, each bearing 26 comprises a number 20 of rolling members 26a each made of ceramic, an inner ring 26b and an outer ring 26c each of which is made of steel.

[0019]

 The housing 27 has an upper protrusion 27a formed with, for example, two stepped portions. The upper stepped portion has a smaller 25 diameter than the lower stepped portion. A polygon mirror 28 is fixed to an outer circumferential portion of the housing 27 by screws 29. The polygon mirror 28 has an outer circumferential surface serving as a reflecting surface. A lower portion of an inner circumferential surface of

the polygon mirror 28 is fitted with the stepped portion of the protrusion 27a with a larger diameter. As a result, a groove 30 is defined between a smaller diameter portion of the protrusion 27a and the polygon mirror 28.

[0020]

5 A rotor yoke 31 is bonded to a lower portion of the housing 27, for example. The rotor yoke 31 extends downward along an outer circumferential surface of the stator core 22. A rotor magnet 32 is fixed to an inner circumferential surface of the rotor yoke 31 so as to be opposed to the stator core 22 with a predetermined gap therebetween.

10 The housing 27, polygon mirror 28, rotor yoke 31 and rotor magnet 32 constitute a rotor assembly 33.

[0021]

An oil-mist preventing cap 34 is attached to an upper portion of the upper ball bearing 26. A stop ring 35 is fitted with the upper end of the 15 shaft 25. A coil spring 36 is provided around the upper portion of the shaft 25 between the cap 34 and the stop ring 35. The coil spring 36 urges the inner ring 26b of the upper ball bearing 26 downward and the inner ring 26b of the lower ball bearing 26 upward.

[0022]

20 A printed circuit board 37 is mounted on the base 21. The foregoing light deflecting motor is so arranged as to control energization of the stator coil 22 by a drive circuit mounted on the printed circuit board 37 so that the rotor 33 is rotated, although a detailed description is eliminated.

[0023]

25 A balancing weight 38 is secured to the bottom 30a of the groove 30 so that the balance adjustment is carried out for the rotor assembly 37. Accordingly, the bottom 30a of the groove 30 serves as a balancing surface. The weight 38 comprises an adhesive agent made from a resin

and hardened when subjected to ultraviolet rays, for example. In this case, the bottom 30a of the groove 30 is substantially coplanar with a plane which is at a right angle to a central axis of the fixed shaft 25 and further which involves the center of gravity of the rotor assembly 33 as 5 shown by reference symbol " G" in FIG. 1. The center of gravity G of the rotor assembly 33 is located between the two ball bearings 26.

[0024]

The operation of the embodiment will now be described. The polygon mirror 28 is rotated when the stator coil 23 is energized so that 10 the rotor assembly 33 is driven. Since the center of gravity G of the rotor assembly 33 is located between the upper and lower ball bearings 26, the rotor assembly can be prevented from being rotated like a pestle with oscillation during high-speed rotation. Moreover, the balancing surface (namely, the bottom 30a of the groove 30) is coplanar with the plane which 15 is at a right angle to the central axis of the fixed shaft 25 and further which involves the center of gravity G of the rotor assembly 33. Consequently, since no gyroscopic moment occurs in the rotor assembly 33 even when it is rotated at high speeds, an amount of oscillation of the overall rotor assembly 33 and more specifically, of the polygon mirror 28 20 can be reduced.

[0025]

Further, the center of gravity G of the rotor assembly 33 is located between the upper and lower ball bearings 26. Accordingly, even if the motor has a single balancing surface, the balance adjustment can 25 sufficiently be carried out for the rotor assembly 33. Consequently, the balance adjustment can be performed more easily in the aforesaid motor as compared with the prior-art construction employing the two balancing surfaces.

[0026]

FIG. 2 illustrates a second embodiment of the invention. Only the difference between the first and second embodiments will be described. Identical or similar parts in the second embodiment are labeled by the 5 same reference numerals as in the first embodiment.

[0027]

In the second embodiment, the light deflecting motor has a balancing groove 41 formed in a lower end of an outer circumferential face of the rotor yoke 31. Accordingly, a balancing weight 42 comprising the 10 ultraviolet hardening resin is secured to the bottom of the groove 41 as well as to the bottom of the groove 30 in the second embodiment.

[0028]

In other words, the balance adjustment is carried out on two faces of the grooves 30 and 41 respectively in the embodiment. As a result, since 15 the balance adjustment is carried out radially and axially with respect to the rotor assembly 33, the overall rotor assembly can effectively be balanced and the radial and axial oscillations of the rotor assembly during high-speed rotation can be reduced.

[0029]

20 Further, in this embodiment, the groove 41 is disposed in the lower end of the rotor yoke 31 which is axially farthest from the center of gravity G in the rotor assembly 33. Consequently, the balance adjustment can accurately be carried out with a smaller mount of balancing weight 38 in the groove 41.

25 [0030]

Moreover, since the balancing weight 38 is accommodated in the groove 41, it can be prevented from centrifugally flying out of the groove. Further, if the balancing weight 38 flies out of the groove or is broken to

be scattered, scattered pieces of the weight 38 can be prevented from adhering to the reflecting surface of the polygon mirror 28 since the groove 41 is located inside as compared with the reflecting surface. Additionally, since the groove 41 is formed integrally with the rotor yoke 5 31, an increase in the number of parts can be prevented.

[0031]

FIG. 3 illustrates a third embodiment of the invention. Only the differences between the second and third embodiments will be described. Identical or similar parts in the third embodiment are labeled by the same 10 reference numerals as in the second embodiment.

[0032]

In this embodiment, a flange 51 is formed integrally on a lower circumferential edge of the housing 27. The flange 51 is radially opposed to the outer circumferential face of the rotor yoke 31. The groove 41 is 15 formed in the outer circumferential portion of the lower end of the flange 51 in the third embodiment although it is formed in the lower end of the rotor yoke 31 in the second embodiment.

[0033]

In this construction, too, the balancing weights 38 are secured in 20 both grooves 31 and 41 respectively so that the balance adjustment is carried out. Consequently, the same effect can be achieved in the third embodiment as in the second embodiment.

[0034]

FIG. 4 illustrates a fourth embodiment of the invention. Only the 25 differences between the second and fourth embodiments will be described. Identical or similar parts in the fourth embodiment are labeled by the same reference numerals as in the second embodiment.

[0035]

In this embodiment, a flange 61 is formed integrally on a lower circumferential edge of the housing 27. The flange 61 is radially opposed to the outer circumferential face of the rotor yoke 31. In the fourth embodiment, the groove 41 is defined by the rotor yoke 31 and the flange 61. Accordingly, in the fourth embodiment, too, the balancing weights 38 are secured in both grooves 31 and 41 respectively so that the balance adjustment is carried out. Consequently, the same effect can be achieved in the fourth embodiment as in the second embodiment. The balancing weight 38 secured in the groove 41 is made of, for example, a 10 thermosetting resin since ultraviolet rays cannot be irradiated onto the groove.

[0036]

FIG. 5 illustrates a fifth embodiment of the invention. Only the differences between the first and fifth embodiments will be described. 15 Identical or similar parts in the fifth embodiment are labeled by the same reference numerals as in the first embodiment.

[0037]

Dynamic pressure air bearings are used in this embodiment. More specifically, the housing 27 has a centrally formed axial through hole 71 in 20 which the fixed shaft 25 is inserted, as shown in FIG. 5. A gap of several μm is defined between the inner circumferential face of the hole 71 and the outer circumferential face of the shaft 25. The shaft 25 has two pairs of herringbone grooves 72 formed in the outer circumferential face of a portion of the shaft 25 located in the hole 71. Accordingly, two dynamic 25 pressure air bearings 73 are constituted by the portion of the outer circumferential face formed with the grooves 72 and the inner circumferential face of the hole 71.

[0038]

In the above-described construction, too, the center of gravity of the rotor assembly 33 is located between the dynamic pressure air bearings 73 in the fifth embodiment. The other construction of the motor of the fifth embodiment is substantially the same as that of the first embodiment.

5 Accordingly, the same effect can be achieved from the fifth embodiment as from the first embodiment.

[0039]

The invention should not be limited to the embodiments described above with reference to the accompanying drawings and may be modified 10 as follows, for example.

Three or more bearings may be provided, instead of two.

Each ball bearing may be made of ceramic in its entirety. Although the manufacturing cost is increased in this case, the wear and abrasion resistance and heat resistance of the ball bearings can be improved. 15 Consequently, the service life of each ball bearing can be improved and errors in the accuracy can be prevented.

[0040]

In each embodiment, the invention is applied to the light deflecting motor of the radial gap type in which the stator and rotor magnet are 20 disposed to be radially opposed to each other. However, the invention may be applied to a light deflecting motor of the axial gap type in which a stator and a rotor magnet are disposed to be axially opposed to each other. Further, the invention may be applied to motors of the inner rotor type in 25 which a stator is disposed outside the rotor as well as motors of the outer rotor type in which a stator is disposed inside the rotor.

[0041]

The balancing groove is located in the lower end of the housing, the lower end of the rotor yoke, and between the housing and the rotor yoke

in the foregoing embodiments. The location of the balancing groove should not be limited to them. The balancing groove may assume any location below the bearings on the rotor assembly. For example, the groove may be provided on the rotor magnet.

5 [0042]

The groove is provided between the housing and the polygon mirror and the bottom of the groove serves as the balancing plane in the foregoing embodiments. However, either housing or polygon mirror may be formed with the groove having the bottom serving as the balancing 10 plane, instead.

[0043]

[Effect of the invention]

As obvious from the foregoing description, according to the light deflecting electric motor of the present invention, the rotor assembly has a 15 center of gravity located between the bearings, and a balancing plane is provided in the vicinity of a plane which is perpendicular to a center of rotation of the rotor assembly and passes the center of gravity of the rotor assembly. Accordingly, even if unbalance occurs on the balancing plane as the result of balancing, the occurrence of gyroscopic moment can be 20 prevented in the rotor assembly during the high-speed rotation, whereupon the rotor assembly can be prevented from being oscillated. Further, since the center of gravity of the rotor assembly is located between the bearings, the rotor assembly can be prevented from being oscillated even when unbalanced.

25 [Brief description of the drawings]

[FIG. 1]

A longitudinally sectional front view of a first embodiment in accordance with the present invention;

[FIG. 2]

A view similar to FIG. 1, showing a second embodiment in accordance with the invention;

[FIG. 3]

5 A view similar to FIG. 1, showing a third embodiment in accordance with the invention;

[FIG. 4]

A view similar to FIG. 1, showing a fourth embodiment in accordance with the invention;

10 [FIG. 5]

A view similar to FIG. 1, showing a fifth embodiment in accordance with the invention; and

[FIG. 6]

A view similar to FIG. 1, showing a conventional construction.

15 [Explanation of reference symbols]

In the figures, reference symbol 21 designates a base, 24 a stator, 25 a fixed shaft, 26 ball bearings, 26a rolling members, 27 a housing (a rotating member), 28 a polygon mirror, 31 a rotor yoke, 32 a rotor magnet, 33 a rotor assembly, 41 a balancing groove, and 73 dynamic pressure air 20 bearings.